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TITAN
INFORMATION SYSTEMS

March 1, 1995

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William F. Caton
Office of the Secretary
Federal Communications Commission
Room 222
1919 M Street, N.W.
Washington, D.C. 20554

Re: Amendment of Parts 2 and 15 of the Commission's Rules to Permit Use of Radio Frequencies Above 40 GHz for New Radio Applications
ET Docket No. 94-124 RM-8308

Dear Mr. Caton:

Enclosed on behalf of Titan Information Systems Corporation are the original and ten copies of our Reply Comments of the above referenced proceeding.

Please address any questions concerning these Comments to the undersigned.

Sincerely,

TITAN INFORMATION SYSTEMS CORPORATION

Charles F. Newby
Vice President & General Manager
Broadcast Communications

Enclosures

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ORIGINAL

Before the

FEDERAL COMMUNICATIONS COMMISSION

Washington, D.C. 20554

In the Matter of	)	
	)	
Amendment of Parts 2 and 15	)	ET Docket No. 94-124
of the Commission's Rules to Permit	)	RM-8308
Use of Radio Frequencies Above 40 GHz	)	
for New Radio Applications	)	
	)	

REPLY COMMENTS OF TITAN INFORMATION SYSTEMS CORPORATION

March 1, 1995

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SUMMARY

Titan Information Systems Corporation ("Titan") supports the Federal Communication Commission's ("Commission") proposal to license portions of the 40 GHz band for commercial use. Titan does not believe that the Commission intended for the instant proceeding to be used to argue the merits of relocating Local Multi-point Distribution Service ("LMDS") to the 40 GHz band. However, since the opponents of LMDS have used this Notice of Proposed Rule Making ("NPRM") to do exactly this, Titan believes strongly that it must reply to these NPRM Comments in order to correct the public record.

The comments of some parties to the instant proceeding seem to ignore evidence already in the public record regarding the demonstrated public benefits of the LMDS system proposals that are before the Commission. Each of these parties argue that the public interest will be served if the Commission were to move LMDS to the 40 GHz band. There is no public record to support the parties' claims and the arguments the parties use to support their claims that LMDS is technically and economically viable at 40 GHz, are incorrect and without merit.

LMDS is Not Technically Viable at 40 GHz. Moving LMDS to spectrum within the 40 GHz band will not resolve the spectrum allocation issue as the opponents of LMDS claim -- this action by the Commission would, however, completely eliminate LMDS as a competitive alternative to Cable for the delivery of multi-channel television, telephony and other information services. This unintended result would clearly not be in the public interest.

Analysis shows that the propagation characteristics of radio waves at 40 GHz render it unusable for LMDS and, furthermore, even if this frequency was viable for LMDS, the current state-of-the-art in microwave systems and components technology means that the equipment required to deploy a commercially viable LMDS system at 40 GHz is unavailable now and in the foreseeable future. The opponents of LMDS submit an incomplete analysis of the propagation of radio waves at 40 GHz. Technical analysis shows several important results: 1) within the New York City area, radio wave transmissions in a cell of 3 mile radius will experience excessive attenuation (28.1 dB) during a 15 milliliter/hour rainfall to provide the required 99.9% system availability; 2) cost-effective subscriber antennas that achieve the cross polarization isolation required for frequency reuse cannot be built today or in the foreseeable future; 3) the data on reflection and diffraction of radio waves at 40 GHz is inconclusive; and 4) the affects due to the difference in attenuation of foliage at 40 GHz are important.

Moreover, while holding other system design parameters constant, the difference in attenuation due to rainfall for a 99.9% system availability is 11.9 dB. This difference is severe and requires that the LMDS system design be radically altered.

Most importantly, due to the lack of proper cross polarization isolation in cost-effective subscriber antennas, frequency reuse in the 40 GHz band will not be possible. Thus, 3 GHz of spectrum (or three times the bandwidth, possibly more) will be required for each system operator if LMDS is moved into the 40 GHz band. In view of the aforementioned considerations, LMDS is not technically viable within the 40 GHz band now or in the foreseeable future.

LMDS is Not Economically Viable at 40 GHz. The opponents of LMDS claim that LMDS is economically viable in the 40 GHz band. They seek to support their claim by using Europe's Multi-point Video Distribution System ("MVDS") as evidence of a comparable service whose equipment and infrastructure economics are similar. There is no commercial MVDS service operating anywhere in the world. Moreover, even if MVDS was near-operational, it is clear that MVDS is not intended to provide the broadband interactive local-loop alternative that LMDS provides.

The differing economics of LMDS at the 40 GHz band are due to the severe signal attenuation during even moderate rainfall and the lack of spectrum reuse at 40 GHz. Since one cannot decrease system availability, system costs would have to be increased in order to pay for higher performance. It is estimated that hub costs, if they could be built, will double due to the costly Traveling Wave Tube Amplifiers ("TWTAs"), RF upconverters and antennas at 40 GHz; the cost of the Subscriber Antenna will at least double; and the cost of the Subscriber Receiver will increase by more than 50% in order to handle the increased dynamic range and marginal performance requirements. At 40 GHz, LMDS per subscriber equipment costs will be increased by between 7 and 14 times the current cost thus making it non-competitive with other forms of multi-channel television service.

The Commission Should License LMDS at 28 GHz Without Delay. Titan believes that the Commission should give full consideration to the immediate and long-term public interest benefits that would accrue by allowing the immediate full-scale deployment of LMDS. As the Commission realizes, the American consumer's appetite for high-quality, low-cost multi-channel television, telephony and data service remains unfulfilled.

No other available system that combines all of the essential attributes required for a multi-channel television and information service is commercially viable. The benefits of the full-scale deployment of LMDS in its current form will produce enormous public benefits.

In light of the foregoing, the Commission should move without delay to convene the proceedings necessary begin the judicious licensing of LMDS within the 28 GHz band. The Commission should use prudence and due care to ensure that the benefits of the public spectrum accrue to the public and not the powerful commercial interests that have a huge stake in delaying the deployment of LMDS systems throughout the nation.

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REPLY COMMENTS OF TITAN INFORMATION SYSTEMS CORPORATION

1 Introduction

Titan Information Systems Corporation ("Titan") respectfully submits Reply Comments to the Federal Communications Commission's ("Commission") Notice of Proposed Rule Making ("NPRM") in the above-captioned proceeding. Titan has a strong interest in the Commission's rule making regarding the Amendment of Parts 2 and 15 of the Commission's Rules to Permit Use of Radio Frequencies Above 40 GHz for New Radio Applications in general and the comments in the instant proceeding in particular because of Titan's substantial involvement in and familiarity with the development, manufacture, sale and service of systems and technologies used in the delivery of communications services proposed by the Commission within the 40 GHz band. Titan's primary interest in the instant proceeding is to correct the public record by replying to comments submitted in this proceeding.

Recently formed Titan Information Systems Corporation, through its parent The Titan Corporation, has a long history in the design, development, manufacture and service of advanced communications systems using satellite, microwave, optical and wireline propagation means. Importantly, The Titan Corporation, through its Linkabit Division, is the inventor of the conditional access/encryption technology used for satellite television known as VideoCipher®[1]. This technology has become the de facto U.S. standard for conditional access/encryption and is used today by the cable industry to meet its obligations to the program copyright-holder to protect from theft the programming transmitted via satellite to cable headends throughout the U.S. Indeed there are over 125 U.S. cable channels that encrypt their satellite programming using this technology today with an estimated 3,000,000 plus receivers that use this technology to decrypt

[1] VideoCipher is now a trademark of General Instrument Corporation. DigiCipher and DigiCable are also trademarks of General Instrument Corporation.

this programming in operation. This technology owned by The Titan Corporation is used by General Instrument Corporation as the conditional access/encryption subsystem in its DigiCipher™ digital satellite television system. General Instrument Corporation will also use this conditional access/encryption technology in its DigiCable™ product when it is fielded late in 1995 or 1996.

The Titan Corporation has recently formed Titan Information Systems Corporation in order to deploy this vital technology into conditional access/encryption equipment for Satellite, Cable, Video Dial Tone, Multi-point Microwave Distribution Service, and Local Multi-point Distribution Service ("LMDS") systems in the U.S. and internationally. Titan has committed considerable research and development resources to develop a conditional access/encryption system that meets the unique requirements of LMDS. It is from this vantage point that Titan respectfully offers the Commission important information concerning the technical and economic soundness of the Comments before the Commission in the instant proceeding.

2 Reply to the Comments Before This NPRM.

Titan supports the Commission's proposal to license portions of the 40 GHz band for commercial use. However, Titan does not believe that the Commission intended for the instant proceeding to be used to argue the merits of relocating LMDS to the 40 GHz band[2] . Since the opponents of LMDS have used this NPRM to do exactly this, Titan believes that it must reply to these NPRM Comments ("Comments") in order to correct the public record.

It is clear from the Comments submitted in this NPRM that there are deep divisions between the proponents and opponents of LMDS. Apparently, these divisions are so deep that certain parties to the instant proceeding have deemed it necessary to ignore good scientific and economic principles when presenting their arguments. In our NPRM Reply Comments ("Reply Comments") Titan will endeavor to use accepted scientific and economic analysis methods in order to sharpen the focus on some of the arguments presented in the Comments submitted in this NPRM.

2.1 Reply to Comments Asserting That Moving LMDS From 28 GHz to 40 GHz Will Serve the Public Interest.

The Comments of certain parties to the instant proceeding, including Hughes Communications Galaxy Inc. ("Hughes"), Teledesic Corporation ("Teledesic") and the National Aeronautics and Space Administration ("NASA"), seem to ignore evidence already in the public record regarding the demonstrated public benefits of the LMDS system proposals currently before

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[2] Throughout the numerous LMDS proceedings the Commission has never suggested that the 40 GHz band is appropriate for LMDS. In fact the Commission has indicated its understanding of the technical difficulties in locating LMDS within the 40 GHz band by stating that "we will not grant further consideration to [these] suggestions since there is no evidence in the record that the beneficial uses we anticipate from point-to-multi-point use of the 28 GHz band are likely to materialize at the higher bands". See, Second Notice of Proposed Rulemaking, CC Docket No. 92-297 ("Second NPRM").

the Commission. The parties argue that public interest will be served if the Commission were to move LMDS to the 40 GHz band. However, there is no public record to support the parties' claims and, as Titan indicates below, the arguments that the parties put forth do not support their claims that LMDS is technically and economically viable at 40 GHz.

LMDS is not now, nor will it be in the foreseeable future, technically or economically viable within the 40 GHz band. Even if LMDS were viable in this band, the public interest would still favor allocating the 28 GHz band to LMDS. As the Commission is aware, the Suite 12 Group, their affiliates and the equipment manufacturers with whom they have contracted, have expended very significant research and development as well as manufacturing resources in order to move this unique new technology from the research and development phase into full-scale deployment. If the Commission were to follow the recommendations of Hughes, NASA and Teledesic, the hundreds of man-years and many tens of millions of dollars that have been devoted to the development of this technology would be lost.

Public interest is better served by dedicating spectrum within the 40 GHz band to new short range communication services that can benefit from the unique characteristics of the 40 GHz band. Ironically, some of the services proposed by Hughes and Teledesic fit the technical and economic profile required to make good use of spectrum within the 40 GHz band. Indeed, satellite-based telecommunications services such as those proposed by Hughes and Teledesic have substantial margin to increase power output without incurring an economic burden.

Finally, moving LMDS to spectrum within the 40 GHz band will not resolve the spectrum allocation issue as Hughes, NASA and Teledesic claim. This action by the Commission would, however, completely eliminate LMDS as an competitive alternative for the delivery of multi-channel television, telephony and other information services. This unintended result would clearly not be in the public interest.

2.2 Reply to Comments Asserting That LMDS is Technically Viable at 40 GHz.

The arguments used by Hughes, NASA and Teledesic to support their claims that LMDS is technically feasible at 40 GHz can be summarized as follows: Since the propagation characteristics of radio waves at 40 GHz are similar to those at 28 GHz and LMDS is feasible in the 40 GHz band from an equipment standpoint, then LMDS should be moved to the 40 GHz band. Titan will show below that the propagation characteristics of radio waves at 40 GHz render it unusable for LMDS. Furthermore, even if the frequency were viable for LMDS, the current state-of-the-art in microwave systems and components technology means that the equipment required to deploy a commercially viable LMDS system at 40 GHz is unavailable now and in the foreseeable future.

Hughes, NASA and Teledesic all submit an incomplete analysis of the propagation of radio waves at 40 GHz. Teledesic uses the small signal attenuation of water vapor and oxygen at 40 GHz (0.47 dB for a cell of 3 mile radius) to argue that there is only a small and insignificant difference in the propagation of radio waves at 28 GHz and 40 GHz, while ignoring the well

known affect of rain attenuation at these frequencies. NASA fails to present any propagation analysis at all. Hughes presents propagation analysis[3] for LMDS systems operating at 40 GHz but draws a series of conclusions not supported by the results of their analysis.

Titan's technical analysis, presented in as Exhibit A attached hereto and incorporated herein, shows several important results: 1) Within the New York City area, a radio wave transmission in a cell of 3 mile radius will experience an attenuation of 28.1 dB during a 15 milliliter/hour rainfall (for a 99.9% system availability); 2) cost-effective subscriber antennas that achieve the cross polarization isolation required for frequency reuse cannot be built today or in the foreseeable future; 3) the data on reflection of radio waves at 40 GHz is inconclusive; and 4) the affects due to the difference in attenuation of foliage at 40 GHz are important.

Importantly, while holding other system design parameters constant, Titan finds that the difference in attenuation due to rainfall for a 99.9% system availability is 11.9 dB. This difference is quite severe and requires that the LMDS system design must be radically altered. Several system design options are available. For instance, higher power TWTAs, higher gain transmit antennas, and/or larger receive antennas could be used. Each of these apparent "solutions" to the rain attenuation problem seem reasonable but would, in practice, be difficult to implement. First, higher power TWTAs at 40 GHz are not available at any price and available units cannot be combined effectively in order to achieve the required power levels due to difficulties in linearizing the tubes across the 1 GHz transmission band (the frequency tilt problem). Second, using higher gain transmit antennas would narrow the vertical beam-width to an extent that near-field subscribers would become shadowed. Third, doubling the size of the receive antenna is not practical or desirable for several reasons: a larger flat plate patch antenna will exhibit no gain due to branching losses, landlords will not permit the installation of larger antennas on the side of buildings, and higher antenna gain causes narrower beamwidth which causes alignment problems. Finally, and most importantly, analysis shows that a cost-effective 40 GHz subscriber receiver/antenna that meets the cross polarization isolation requirement cannot be manufactured now or in the foreseeable future.

Hughes, NASA and Teledesic simply ignore the affects of signal attenuation due to rain by making the erroneous assertion that system availability can be reduced from 99.9% to either 99.84% or 99.75%. This decrease in system availability is not possible since the resultant signal quality will seriously impact the dependability of the LMDS service. In addition, this decrease in availability will seriously impact the proper function of the conditional access/encryption system used with the service. While the conditional access/encryption system design uses a robust communications channel, it still requires a high-availability channel in order to achieve the degree of subscriber satisfaction required by a commercially viable service.

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[3] See generally the instant NPRM Comments of Hughes Communications Galaxy Inc., Exhibit A, the Stanford Telecom Report on LMDS at 40 GHz.

Finally, and most importantly, Titan finds that, due to the fact that cost-effective subscriber antennas with the required cross polarization isolation cannot be built today or in the foreseeable future, frequency reuse in the 40 GHz band will not be possible. Thus 3 GHz of spectrum (and possibly more) will be required for each system operator if LMDS is moved into the 40 GHz band. From analysis, Titan concludes that now and in the foreseeable future, LMDS is not technically feasible within the 40 GHz band.

2.3 Reply to Comments Asserting That LMDS is Economically Viable at 40 GHz.

Hughes, Teledesic and NASA each claim that LMDS is economically viable in the 40 GHz band. They seek to support their claim by using Europe's Multi-point Video Distribution System ("MVDS") as evidence of a comparable service whose equipment and infrastructure economics are similar.

Titan knows of no commercial MVDS service operating anywhere in the world. Teledesic, in its NPRM Comments, claims to know of an MVDS service set to begin operation this year. While the exact nature of the intended service is unclear, it is worth noting that this system, according to Teledesic is supposed to deliver information via digital means. The fact is that the first MVDS system will be analog and will transition to digital only if and when appropriate digital technology becomes available. While the transmission of digital data in the higher frequency bands is possible, the use of digital technology is economically too burdensome today and its use would put LMDS at an economic disadvantage versus Cable. Furthermore, the European Conference of Postal and Telecommunications Administrations' (CEPT) designation of 40.5-42.5 GHz for MVDS and the issues that this organization addressed with its recommendation for a limited analog one-way system are irrelevant to the issues surrounding the deployment of LMDS service.

Next, the differing economics of LMDS at the 40 GHz band are primarily due to the severe signal attenuation during even moderate rainfall at 40 GHz and that the fact that the spectrum cannot be reused. Since, as indicated above, one cannot decrease system availability, system costs would have to be increased in order to pay for higher performance hub and subscriber equipment. It is estimated that hub costs will double due to the costly TWTAs, RF upconverters and antennas at 40 GHz; the cost of the Subscriber Antenna will at least double; and the cost of the Subscriber Receiver increase by more than 50% in order to handle the increased dynamic range and marginal performance requirements. Finally, due to the inability to reuse the spectrum, approximately 4 times as many hubs and repeater systems will have to be provided. It is clear that, even when 40 GHz component costs approach those of 28 GHz units, the cost of building an LMDS system at 40 GHz will increase from between 7 and 14 times. Clearly this cost burden puts LMDS at a competitive disadvantage versus other multi-channel television delivery services.

3 Licensing LMDS Systems Now Will Serve the Public Interest by Allowing the Full Deployment of a Unique Technology That Allows Several High-value Communications Services to be Delivered Via a Single Cost-effective System.

The Commission should give full consideration to the immediate and long-term public interest benefits that would accrue by allowing the immediate full-scale deployment of LMDS. As the Commission realizes, the American consumer's appetite for high-quality, low-cost multi-channel television, telephony and data services remains unfulfilled. With the passage of the 1992 Cable Act, Congress attempted to answer the American consumer's call for cost and quality reform of the U.S. Cable industry. Congress recognized that true Cable industry reform could only come from effective competition. LMDS is the only commercially available technology that can compete effectively with Cable. In support of this assertion, Titan offers the observation that the per subscriber infrastructure and equipment cost for Cable, Video Dial Tone and Direct Broadcast Satellite services is about $1,000-1,500/subscriber. Comparable costs for LMDS systems are significantly lower, thus LMDS is the only commercially available multi-channel delivery system with the programming, technical flexibility and the economics to compete effectively with Cable.

The many advantages of LMDS are well represented in the public record but a few of the important system features bear repeating. Since LMDS is inherently local and depends on hubs to regenerate and retransmit programming, each new hub construction presents an opportunity to change the mix of programming and the terms "local programming" and "narrow casting" take on new meanings. Today and in the future, LMDS is the only commercially available technology that provides the system operator the opportunity to offer commercial and residential telephony at the cost points, and reliability required to compete effectively with the incumbent Local Exchange and Long Distance Carriers. Due to their lack of capacity, satellites can never effectively compete with LMDS.

Finally, Titan is aware of no other available system that combine all of the essential attributes required for a commercial multi-channel television and information service . The benefits of the full-scale deployment of LMDS in its current form will produce enormous public benefits.

4 The Commission Should Commence Proceedings For the Judicious Licensing of LMDS at 28 GHz Without Delay.

In light of the foregoing, the Commission should move without delay to convene the proceedings necessary to begin the judicious licensing of LMDS within the 28 GHz band. The Commission should use prudence and due care to ensure that the benefits of the public spectrum accrue to the public and not to the powerful commercial interests that have a huge stake in delaying the deployment of LMDS systems throughout the nation.

5 CONCLUSION

Titan respectfully recommends that the Commission adopt rules consistent with the Comments herein in order to ensure the greatest public benefit. Titan asks the Commission to resist the forces that would delay the deployment of LMDS throughout the nation. Titan requests that the Commission begin proceeds that will result in the immediate but judicious licensing of LMDS systems at 28 GHz.

Respectfully submitted,

TITAN INFORMATION SYSTEMS CORPORATION

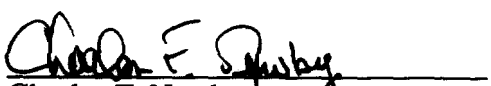
By: 

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Exhibit A

1 **Attenuation Due To Rainfall --** The following analysis compares rain attenuation according to the Crane rain model.

Reference: **Prediction of Attenuation by Rain, IEEE Transactions, Communications, COM-28, 1717-1733, 1980.**

Distance (km):	D = 5	(3.11 miles)
Percentage of rain unavailability:	p = 0.1%	
Percentage of rain availability	99.9% = 100 - p	
Rain rate (mm/hr):	$R_p = 15$	New York, zone D_2

Frequency dependent constants:

f (GHz)	αi	βi
25	0.11	1.09
30	0.17	1.08
35	0.24	1.04
40	0.32	1.00
50	0.48	0.90

Attenuation due to rain (dB) based on the Crane rain model for terrestrial paths:

$$A(R_p, D) = a \cdot R_p^{\beta} \cdot \frac{e^{u\beta d} - 1}{u \cdot \beta} - \frac{b\beta \cdot e^{c\beta d}}{c \cdot \beta} + \frac{b\beta \cdot e^{c\beta D}}{c \cdot \beta}$$

where $b = 2.3 \cdot R_p^{-0.17}$

$c = 0.026 - 0.03 \cdot \ln(R_p)$

$d = 3.8 - 0.6 \cdot \ln(R_p)$

$$u = \frac{\ln(b \cdot e^{c \cdot d})}{d}$$

Rainfall Attenuation:

f (GHz)	A(f)
25	12.8
30	18.5
35	23.8
40	27.7
45	29.8

Using simple interpolation we have:

A(28 GHz) = 16.2 dB

A(41 GHz) = 28.09 dB

Rain attenuation loss difference: **11.89 dB.**

2 **Dispersion Effects** -- Due to the dispersive affects of carriers operating above 35 GHz during clear sky and rainfall conditions, co-channel interference will be increased (Shanmugan, et. al.; "Wideband Digital transmission Through the Atmosphere at EHF Frequencies: Effects of Refractive Dispersion").

In addition, the subscriber antenna cross polarization isolation will decrease from 30 dB to an estimated 20 dB (or less) for cost-effective antennas. This lost in C/I protection ratio will preclude frequency reuse.

3 **Scattering Effects** -- Relevant studies of the reflection effects at 40 GHz are not available so we cannot determine if operation of LMDS at 40 GHz will be able to take advantage of the signal bounce characteristics that are present at 28 GHz.

4 **Foliage Effects** -- Signal propagation through foliage at 40 GHz is expected to increase by 3 dB at 40 GHz. This is an important loss when subscriber antennas are operating in a light foliage LOS situation.